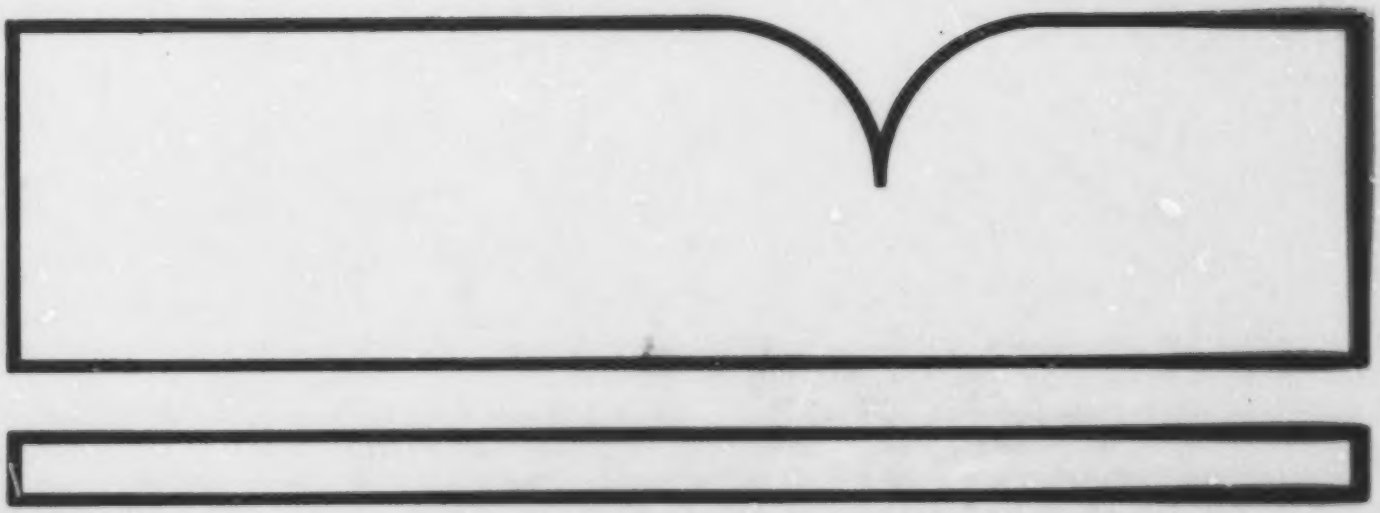
PB82-117870

The Determination of a Range of Concern for Mobile Source Emissions of Sulfuric Acid

(U.S.) Environmental Protection Agency
Ann Arbor, MI

Aug 81



U.S. Department of Commerce
National Technical Information Service
NTIS.

PB82-117870

EPA/AA/CTAB/PA/81-21

The Determination of a Range of Concern for Mobile Source Emissions of Sulfuric Acid

by

Craig A. Harvey

and

Robert J. Garbe

August, 1981

NOTICE

Technical Reports do not necessarily represent final EPA decisions or positions. They are intended to present technical analyses of issues using data which are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments which may form the basis for a final EPA decision, position or regulatory action.

Control Technology Assessment and Characterization Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Office of Air, Noise and Radiation
U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, Michigan 48105

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

Summary

This paper describes an effort by the Emission Control Technology Division of the EPA to establish a range of concern for sulfuric acid (H_2SO_4) emissions from mobile sources. In light of the action called for in section 202(a)(4) of the Clean Air Act (CAA) and due to a concern within industry as to what emission levels will be used as the basis for the evaluation of current and future technologies, a methodology was developed in order to bracket a range of concern for various unregulated pollutants. This paper coordinates the efforts from two EPA contracts in order to use this methodology specifically for an evaluation of sulfuric acid. Mathematical models were previously designed for various exposure scenarios (such as enclosed spaces, expressways, and street canyons) and were used to calculate the ambient air concentrations resulting from various mobile source sulfuric acid emission factors (grams/mile). In conjunction with this, a sulfuric acid health effects literature search was conducted to aid in the determination of the final range of concern. This search provides adequate evidence to support the chosen limits of the range.

The results of this analysis provides a range of concern for sulfuric acid emissions from motor vehicles of from 22-350 mg/mile to 1540-23077 mg/mile depending on the type of scenario chosen to represent public exposure. The available emission factor data indicate that the current vehicle fleet emission factor for sulfuric acid is 12 mg/mile, which is well below the lowest of the ranges of concern for sulfuric acid. The specific emisson control design / vehicle categories that have emission factors most often appearing within the ranges of concern are Heavy Duty Trucks and Light Duty Diesel vehicles with trap-oxidizers (100 mg/mile).

I. Introduction

It was discovered in late 1972 that catalyst equipped vehicles operating on unleaded fuel had substantially higher particulate emissions than non-catalyst vehicles operating on unleaded fuel(1)*. Analysis of the particulate samples taken from catalyst cars showed mostly hydrated sulfuric acid to be present(2). Analysis of particulate samples collected from non-catalyst vehicles have also shown sulfate but at much lower levels(1,2,).

The results of four subsequent studies of motor vehicle sulfate emission were compiled by EPA for the report to Congress called for in the Clean Air Act Section 403G as amended August 1977. Some of the major conclusions from this were:

1) Oxidation catalyst-equipped passenger vehicles emit significantly more sulfate (sulfuric acid) than either production or prototype gasoline-fueled passenger vehicles without catalysts.

2) Laboratory-maintained production vehicles exhibit higher sulfate emissions than do consumer-owned production vehicles. Deterioration or alteration of the emission control system(s) of consumer-owned/maintained vehicles increases regulated gaseous emissions (i.e., HC, CO, and NOx) and decreases sulfate emissions from these vehicles.

3) Diesel trucks exhibit the highest measured vehicular sulfate emission rate, 50 mg/mile.

Health effects research on sulfuric acid has been conducted including *in vitro*, *in vivo*, and human epidemiology studies. Since sulfuric acid contained in an aerosol is particulate matter, its toxicity depends to some extent on its deposition and retention in the respiratory tract. The acid is considerably more potent than sulfur dioxide in exerting physiological

*Numbers in parentheses designate references listed at end of report.

effects; for ex- one study showed that sulfuric acid more than tripled the increase in pulmonary ... -istance caused by an equimolar amount of SO_2.

In the interest of establishing a range of concern for levels of H_2SO_4 in motor vehicle exhausts, Midwest Research Institute (MRI) was contracted by EPA to compile information on the health effects of sulfuric acid at different concentrations(3). The results of that work form the basis for the range of concern determined later in this report.

II. Background

When the Clean Air Act was amended in August 1977, the additions included sections 202(a)(4) and 206(a)(3) which deal with mobile source emissions of hazardous pollutants from vehicles manufactured after 1978. These sections are as stated below:

> "(4)(A) Effective with respect to vehicles and engines manufactured after model year 1978, no emission control device, system or element of design shall be used in a new motor vehicle or new motor vehicle engine for purposes of complying with standards prescribed under this subsection if such device, system, or element of design will cause or contribute to an unreasonable risk to public health, welfare, or safety in its operation or function.
>
> (B) In determining whether an unreasonable risk exists under subparagraph (A), the Administrator shall consider, among other factors, (i) whether and to what extent the use of any device, system, or element of design causes, increases, reduces, or eliminates emissions of any unregulated pollutants; (ii) available methods for reducing or eliminating any risk to public health, welfare, or safety which may be associated with the use of such devices, systems, or elements of design which may be used to conform to standards prescribed under this subsection without causing or contributing to such unreasonable risk. The Administrator shall include in the consideration required by this paragraph all relevant information developed pursuant to section 214."

206 (a) (3)

> "(3) (A) A certificate of conformity may be issued under this section only if the Administrator determines that the manufacturer (or in the case of a vehicle or engine for import, any person) has established to the satisfaction of the Administrator that any emission control device, system, or element of design installed on, or incorporated in, such vehicle or engine conforms to applicable requirements of section 202(a)(4).

> (b) The Administrator may conduct such tests and may require the manufacturer (or any such person) to conduct such tests and provide such information as is necessary to carry out subparagraph (A) of this paragraph. Such requirements shall include a requirement for prompt reporting of the emission of any unregulated pollutant from a system device or element of design if such pollutant was not emitted, or was emitted in significantly lesser amounts, from the vehicle or engine without the use of the system, device, or element of design."

Prior to these amendments, EPA's guidance to the manufacturers regarding hazardous unregulated pollutants were contained in the Code of Federal Regulations, Title 40, section 86.078-5b. This subsection is stated as follows:

> "Any system installed on or incorporated in a new motor vehicle (or new motor vehicle engine) to enable such vehicle (or engine) to conform to standards imposed by this subpart:
>
> (i) Shall not in its operation or function cause the emissions into the ambient air of any noxious or toxic substance that would not be emitted in the operation of such vehicle (or engine) without such system, except as specifically permitted by regulation; and
>
> (ii) Shall not in its operation, function, or malfunction result in any unsafe condition endangering the motor vehicle, its occupants, or persons, or property in close proximity to the vehicle.
>
> (2) Every manufacturer of new motor vehicles (or new motor vehicle engines) subject to any of the standards imposed by this subpart shall, prior to taking any of the action specified in section 203 (a)(1) of the Act, test or cause to be tested motor vehicles (or motor vehicle engines) in accordance with good engineering practice to ascertain that such test vehicles (or test engines) will meet the requirements of this section for the useful life of the vehicle (or engine)."

Before certification can be granted for new motor vehicles, manufacturers are required to submit a statement, as well as data (if requested by the Administrator), which will ascertain that the technology for which certification is requested complies with the standards set forth in section 86.078-5(b). This statement is made in section 86.078-23(d).

The EPA issued an Advisory Circular (AC) (4) in June 1978, to aid the manufacturers in complying with section 202 (a)(4). Manufactureres were

asked to continue providing statements showing that their technologies did comply with the vehicle emission standards and also will not contribute to an unreasonable risk to public health. Another Advisory Circular (5) was issued in November of that year continuing these procedures for 1980 and later model years.

III. Methodology Overview

Along with the previously mentioned activities, EPA, with the input from several interested parties, has developed a methodology which is one possible approach to implementing section 202 (a)(4) of the CAA. This approach is explained in detail in EPA report number EPA/AA/CTAB/PA/81-2, "An Approach for Determining Levels of Concern for Unregulated Toxic Compounds from Mobile Sources" (6). Only a brief summary of this method will be presented in this report.

Under contract to EPA, Southwest Research Institute (SwRI), and Midwest Research Institute (MRI), have provided valuable information for this effort. SwRI developed or modified mathematical models for predicting ambient air concentrations of mobile source pollutants for a variety of exposure situations including enclosed spaces, street canyons, and expressways. Once vehicle emission factors for various vehicle categories have been determined for a particular pollutant, these models can then be used to calculate corresponding ambient air values for both severe and typical exposure situations for each scenario. A plot of ambient air concentrations vs. emission factors can then be designed for use in further steps of this methodology.

Health effects literature searches have been and are being conducted by MRI in an attempt to aid EPA in the determination of a range of concern for various selected pollutants. With adequate information, the limits for this range can be chosen. The upper level of the range will be that value above which the studies show that the pollutant causes so great a hazard to human health as to require formal rulemaking action. The lower value of the range will be the lowest level at which there is evidence of adverse physiological effects. The region between these limits will be termed the "ambient air range of concern",

indicating scattered data points providing evidence of adverse physiological effects caused by exposure to various concentrations of sulfuric acid. Using the ambient air vs emission factor plot developed earlier, any technology emitting a concentration of a pollutant (when converted to ambient air concentrations) falling within the range of concern will be subject to closer scrutiny. Technologies with emission levels falling below the lowest level of the range will constitute "no problem", implying a low level of effort monitoring. Technologies with emission levels which fall above the highest value of the range will be considered "dangerous" with respect to human health and, therefore, this will imply a necessity for regulation.

For the purpose of this report, this particular methodology has been used to develop a range of concern specifically for motor vehicle emissions of sulfuric acid.

IV. General Information

Sulfuric acid (H_2SO_4) is a colorless, odorless, extremely corrosive, oily liquid, sometimes called oil of vitriol. Concentrated sulfuric acid has a very strong affinity for water. It is sometimes used as a drying agent and can be used to dehydrate (chemically remove water from) many compounds, e.g., carbohydrates. It reacts with the sugar sucrose, $C_{12}H_{22}O_{11}$, removing eleven molecules of water, H_2O, from each molecule of sucrose and leaving a brittle spongy black mass of carbon and diluted sulfuric acid. The acid reacts similarly with skin, cellulose, and other plant and animal matter. When the concentrated acid mixes with water, large amounts of heat are released.

Sulfuric acid is one of the most important industrial chemicals. More of it is made each year than is made of any other manufactured chemical; nearly 30 million tons of it were produced in the United States in 1970. It has widely varied uses and plays some part in the production of nearly all manufactured goods. The major use of sulfuric acid is in the production of fertilizers e.g., superphosphate of lime and ammonium sulfate. It is widely used in the manufacture of chemicals, e.g, in making hydrochloric acid, nitric acid, sulfate salts, synthetic detergents, dyes and pigments, explosives, and drugs. It is used in petroleum refining to wash impurities out of gasoline

and other refinery products. Sulfuric acid is used in processing metals, e.g., in pickling (cleaning) iron and steel before plating them with tin or zinc. Rayon is made with sulfuric acid. It serves as the electrolyte in the lead-acid storage battery commonly used in motor vehicles (acid for this use, containing about 33% H_2SO_4 and with specific gravity about 1.25 is often called battery acid).

There are two major processes (lead chamber and contact) for production of sulfuric acid, and it is available commerically in a number of grades and concentrations. The lead chamber process, the older of the two processes, is used to produce much of the acid used to make fertilizers; it produces a relatively dilute acid (62%-78% H_2SO_4). The contact process produces a purer, more concentrated acid but requires purer raw materials and the use of expensive catalysts. In both processes sulfur dioxide is oxidized and dissolved in water(7).

Sulfuric acid from motor vehicles occurs via two basic processes, both of which begin with some of the sulfur in the fuel oxidizing to sulfur dioxide (SO_2) during combustion. After this, in vehicles equipped with oxidation catalysts, some of the SO_2 is further oxidized by the catalyst to sulfur trioxide (SO_3) which can then combine with water to form sulfuric acid. The other route by which sulfuric acid is formed is the photochemical oxidation of exhaust sulfur oxides to sulfuric acid and sulfate by natural processes in the atmosphere(8).

Typical ambient public exposure to sulfuric acid is due to inhalation of suspended sulfuric acid particles from a variety of sources such as fossil-fueled industrial facilities. It can come from stationary sources, electric power plants or motor vehicles. Overall automotive sulfuric acid emissions are generally low (2%) in comparison to stationary sources, but it is possible that high localized concentrations could occur under certain high volume traffic conditions.

When sulfuric acid in the form of a suspended aerosol is inhaled, it acts as an irritant to the respiratory tract. At lower exposures (less than 1.0 mg/m^3) and smaller particle sizes (less than 2 um) the effects include slight respiratory irritation and significant changes in mucociliary

clearance. With larger particles or higher exposures the irritation increases, making deep breathing difficult for some and increasing light sensitivity(3,9).

V. Emission Factors

Emission factors for sulfuric acid were collected from a number of available sources and are listed in Table I. These emission factors have been compiled at this time only for the Congested Freeway Driving Schedule. This particular driving schedule is most applicable to the expressway exposure situation, but may still have utility for the street canyon situation. The emission factors for the enclosed space conditions, which would best be derived from an idle or slow speed schedule, will be the subject of further work to identify concrete emission factors for these situations.

While this example is concerned with sulfuric acid only, the emission factors reported here generally are measurements of aqueous soluble sulfates. In most cases, the predominant soluble sulfate species in mobile source exhaust is sulfuric acid (10). However, other sulfates such as ammonium sulfate could be present. For the purposes of this report, it is assumed that the mobile source emission factors represent 100 percent sulfuric acid.

These emission factors can be combined to calculate fleet average emission factors for the vehicle fleet by using available information on vehicle miles traveled (VMT) for the different vehicle classes. For simplicity in this example the VMT fractions will be derived from information in the Pedco report (11) for calendar year 1980 and Mobile Source Emission Factors: For Low Altitude Areas Only (12). In future assessments, other references may be used to perform these calculations. Table II provides a breakdown of the vehicle class VMT's and the fleet average emission factor for sulfuric acid.

Obviously this particular set of calculations does not represent any specific fleet emission factor. Depending on the make up of the vehicle fleet at any point in place or time that is of interest, the fleet emission factor will differ. The most severe case could be considered to be the scenario where high sulfuric acid emitting technology is the predominant member of the vehicle fleet. To address this possibility, and the possible presence

TABLE I

Sulfuric Acid Emission Factors*

Vehicle Category	Sulfuric Acid (mg/mile)** Avg
Light Duty Diesel Vehicles	9
w catalyst	100
w trap Oxidizers	100
Light Duty Diesel Trucks	16
Heavy Duty Diesel Trucks	100
Light Duty Gasoline Vehicles	
Non Catalyst; no air pump	0.2
Non Catalyst; air pump	1.0
Oxidation Catalyst; no air pump	10
Oxidation Catalyst; air-pump	20
3-way Catalyst	4
3-way Plus Oxidation Catalyst; air pump	30
Light Duty Truck	
Non Catalyst	1.0
Catalyst, no air pump	20
Heavy Duty Gasoline Vehicles	4

* Based on congested Freeway Driving Schedule and 0.030 wt % Sulfur for gasoline and 0.2 wt % for Diesel fuel. These emission factors may change with other fuel sulfur levels or test cycles.

** Reference 9, 10, 14, 15, 16, 17.

TABLE II

Fleet Average Emission Factors - Sulfuric Acid*

Vehicle Class	Fraction VMT	Emission Factor (mg/mile)	EFxVMT Fraction
Light Duty Diesel Automobiles	0.015	9.0	0.135
Light Duty Diesel Trucks	0.002	16.0	0.032
Heavy Duty Diesel Trucks	0.027	100.0	2.700
Light Duty Gasoline Vehicles			
Non Cat.; no air pump	0.147	0.2	0.029
Non Cat.; air pump	0.098	1.0	0.098
Ox. Cat.; no air pump	0.289	10.0	2.890
Ox. Cat.; air pump	0.261	20.0	5.220
3-way Cat.; no air pump	0.012	4.0	0.048
3-way Plus Ox. Cat.; air pump	0.008	30.0	0.240
Light Duty Gasoline Trucks			
Non Catalyst	0.096	1.0	0.096
Catalyst	0.010	20.0	0.200
Heavy Duty Gasoline Trucks	0.035	4.0	0.140
Total Fleet Average Sulfuric Acid		11.8 mg/mile	

*These calculations were based on available information from the reference listed above (12, 13) and in Table 1. Buses, which may be a significant source of sulfuric acid emissions under certain conditions, are not included in these fleet averages.

Table III
Sulfuric Acid Emission Factors - Compiled

Fleet Category	mg/mile@
Fleet Average (FA)	12
FA + 25% 3W +OC*	17
FA + 50% 3W+OC	22
FA + 75% 3W+OC	26
100% 3W+OC	30
FA + 25% D+C**	34
FA + 50% D+C	56
FA + 75% D+C	75
100% Diesel Cat.	100
FA + 25% D+To***	34
FA + 50% D+To	56
FA + 75% D+To	75
100% D+To	100

@ Normalized to the Congested Freeway Driving Schedule
* Light Duty Gasoline Vehicle - Three way + Oxidation Catalyst with air pump
** Light Duty Diesel Vehicle - Catalyst equipped
*** Light Duty Diesel Vehicle - Trap-oxidizer equipped

of future technology, the fleet average emission factor can be modified to reflect different proportions of these higher emitting technologies. As a worst case, a vehicle fleet consisting of 100 percent of the highest emitting technology could be calculated.

Table I also presents emission factors for vehicle/emission control categories which are expected to be the highest emitters of sulfuric acid under a variety of conditions. Obviously, it is these technologies, on an individual basis, that might be expected to constitute the most likely source of an unreasonable risk to public health. Since most of these technologies are not yet in common use except on an experimental basis, the potential risk can be considered to be a future concern. To establish bounds on the potential risk from sulfuric acid that these technologies present, they will be considered in a number of hypothetical calculations to comprise 25, 50, 75 and 100 percent of the total vehicle miles traveled.

By using the fleet average emission factors in Table II and the hypothetical calculations listed above, a list of emission factors can be calculated to use in subsequent steps. This list is presented in Table III.

VI. Sulfuric Acid Health Effects

A literature review on the health effects of sulfuric acid was performed as an input to the determination of a range of concern for mobile source emissions of this compound. This literature search is included as Appendix II to this report.

As indicated in the methodology, in order to focus the health effects literature review, a preliminary range of ambient levels has been selected to bracket the region of uncertainty with respect to sulfuric acid health effects. This range has been determined to be 10 ug/m^3 - 1000 ug/m^3 for sulfuric acid. The lower end of this range has been selected to approximate the lowest level at which adverse physiological effects can be detected. The preponderance of the evidence has shown little or no health effects at levels of sulfuric acid below this, although there are some indications that

sensitive subgroups of asthmatics may show some reaction to these levels of sulfuric acid. To as great an extent as possible, this lower level also takes into account the interactions of various pollutants such as SO_2 and H_2SO_4.

The upper level of the range is chosen to be the TLV recommended by NIOSH and the ACGIH as 1000 mg/m^3 (9). Above this level several studies have shown an adverse reaction in healthy subjects which may be harmful under repeated exposures.

VII. Sulfuric Acid Ambient Air Concentrations

By using modeling techniques in conjunction with sulfuric acid emission factors, ambient concentrations can be determined that should bracket the range of possible sulfuric acid emission concentrations from mobile sources.

The range of exposures of the general public to motor vehicle exhaust emissions can be estimated by considering a limited number of specific scenarios. The scenarios selected are all expected to be dominantly influenced by mobile source emissions. Personal garages, parking garages, roadway tunnels, street canyons, and urban expressways have been selected to bracket the range of sulfuric acid concentrations from mobile sources that influence short term health effects in the exposed population. Each scenario is developed as both severe and average exposure situations calculated by the use of existing ambient air modeling techniques. No attempt has been made to determine the cumulative effects of these situations on general public health. Appendix I contains a detailed explanation of the rationale for choosing the specific situations and parameters which lead to the numerical results presented here. Figure one depicts graphically the ambient air concentrations vs motor vehicle emission factors for the eleven specific situations discussed below.

Two personal garage situations are presented, one (average or typical) using a 30 second vehicle warmup time and the other (severe) using a five minute vehicle warmup time. These two situations are intended to simulate summer and winter conditions, respectively.

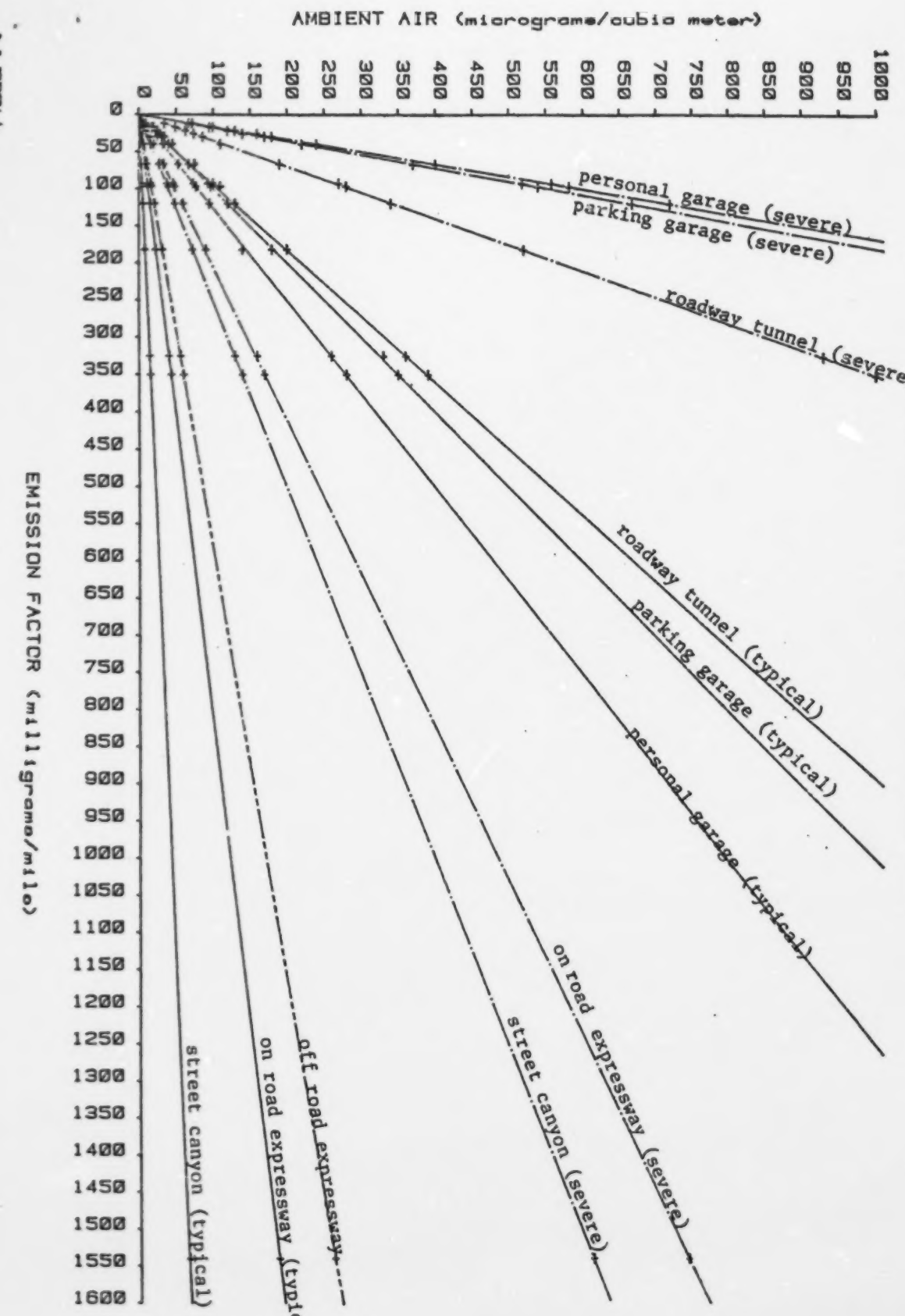


Figure 1

Pollutant Concentrations vs Emission Factors

The two parking garage situations simulate average and severe conditions, with an above ground, naturally ventilated garage for the former and an underground garage for the latter. The average parking garage case is calculated assuming an exit time in which the vehicle spends equal time on the parking level and the ramp level. The severe parking garage is calculated assuming that the exposure takes place 20 minutes after a major sporting event finishes, wherein the exposed population is at parking level 5. The initial concentration of sulfuric acid in this garage is assumed to be low (1 mg/m^3).

The roadway tunnel situations used two different specific tunnels to estimate an average and severe condition. A new design, two lane roadway tunnel with moderate traffic flow is used for average conditions, while an old design, heavily used roadway tunnel is used for severe conditions.

The two street canyon situations are simulated by examining the parameters of two street canyons. The most sensitive parameter in this model appears to be the number of traffic lanes in the canyon. The severe condition is calculated for a six lane street canyon with a 2400 vehicle/hr traffic load and with the exposed population located inside of the vehicle. The typical condition is calculated for a two lane canyon with 800 vehicles/hr of traffic and a sidewalk location of the exposed population.

The expressway situations require three specific estimations to cover the range of possible concentrations. One highway condition tends to estimate an exposure involving a close proximity to the highway such as would be gotten by living or working close to a heavily travelled freeway. This case is calculated on a short term basis for a distance of 50 meters downwind of the roadway. The other two expressway situations simulate a commuter (located in the vehicle) exposure, with the average case using a four lane, medium use (1400 vehicle/hour) and a westerly wind at 1.0 meters/sec and the severe case using a ten lane, heavily travelled (3600 vehicles/hr) freeway with a 1.0 meter/sec westerly wind.

VIII. Determination of the Range of Concern

The range of concern for sulfuric acid emissions from automobiles is determined using the outputs from the previous three areas, emission factors,

health effects and exposure estimation (the emission factors and exposure estimates have already been combined in Table IV). Using the preliminary range (10 ug/m^3 - 1000 ug/m^3) as a stepping stone for this effort, along with the guidelines explained earlier in the methodology section of this report, an upper and lower value can be determined for the final range of concern.

The literature search reveals a human study which shows that an acute exposure concentration as low as 66.0 ug/m^3 caused significant differences in lung function parameters in 3 out of 18 subjects tested (Gardner et. al. 1976). The evidence provided in the literature also shows that no physiological effects were detected for exposure concentrations below 66.0 ug/m^3. Since, at this time, there is no available information definitely concluding that there are adverse physiological effects at concentrations of sulfuric acid below 66.0 ug/m^3, this value will be chosen as the lower value in the range of concern.

The upper value of the range will remain at 1000 ug/m^3 as was set for the preliminary range of concern. This TLV for sulfuric acid is the time-weighted average concentration for a normal 8-hour workday or 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effects. The evidence of adverse health effects above this level would be sufficient to support regulatory action.

Between the chosen limits of this range, there are scattered data points providing evidence of adverse physiological effects caused by exposure to various concentrations of sulfuric acid. Therefore, this region has been termed the "range of concern" for sulfuric acid concentrations in the ambient air.

Once the literature search was completed and the appropriate information was tabulated for sulfuric acid, a large table was prepared compiling all the information for the animal and human studies (see Appendix III). These tables list the studies according to the exposure concentration of sulfuric acid (highest to lowest concentration). Using this health effects information along with the emission factor data presented in Table IV, graphs were

TABLE IV

Emission Factors Required to Result in

Two Different Ambient Sulfuric Acid Levels**

Ambient Situation*	Emission Factor mg/mile for 66 ug/m^3 exposure	Emission Factor mg/mile for 1000 ug/m^3 exposure
Street Canyon - Typical	1540	23077
Expressway - Typical	619	9375
Expressway - Close Proximity	388	5882
Street Canyon - Severe	165	2500
Expressway - Severe	132	2000
Personal Garage - Typical**	-	-
Parking Garage - Typical**	-	-
Roadway Tunnel - Typical	59	822
Roadway Tunnel - Severe	22	350
Parking Garage - Severe**	-	-
Personal Garage - Severe**	-	-

* In order of increasing ug/m^3 concentration for 1 g/mile (or 1 g/min) emission rate.

** These situations were not evaluated for sulfuric acid because of an inadequate data base for emission factors under idle and low speed conditions.

*** If the severe roadway tunnel situation is of primary interest then a fleet emission factor of 22 mg/mile over an appropriate driving schedule will be enough to put the ambient concentration within the range of concern. However, if expressway operation is of primary interest, then emission factors of up to 132 mg/mile would yield ambient concentrations below the range of concern even for severe conditions.

composed representing the relationship between ambient air concentrations, emissions factors, and the various types of public exposure situations (see Figure 2-6).

According to the methodology described earlier in the report, the lower and upper levels which comprise the health effects range of concern are compared to the mobile source situations to calculate the emission factor range of concern. The chief element of comparability between the health effects range and the ambient situations is exposure time. Most of the mobile source situations simulate short term exposures (durations of an hour or less per day) perhaps repeated several times per week over an extended period. The average exposure situations appear more likely to be repeated often, while the severe exposure conditions would likely only occur on infrequent occasions.

With the above information, the mobile source range of concern for sulfuric acid can be estimated for the different mobile source situations. Table IV lists the vehicle emission factors which correspond to the high (1000 ug/m) and low (66 ug/m^3) portions of the range of concern for sulfuric acid. Inspection of this table shows that the scenarios result in a variety of ambient concentrations corresponding to the health effects range of concern of 66 ug/m^3 to 1000 ug/m^3.

IX. Conclusions - Sulfuric Acid

1) The range of concern for sulfuric acid emissions from motor vehicles varies from 22-350 mg/mile to 1540-23077 mg/mile depending on the scenario and situation of interest.

2) The lowest level of this range (22 mg/mile) is based on an ambient air concentration of 66 ug/m^3 for a severe roadway tunnel situation.

3) No vehicle emission factors from the garage scenarios were considered in calculating the range of concern. More data is probably needed on emissions of sulfuric acid from light duty vehicles under idle and slow

speed conditions to evaluate the effects of the garage situations on the sulfuric acid range of concern.

4) The roadway tunnel scenario appears to be a controlling factor in this methodology for the sulfuric acid case. There is some doubt whether this scenario identifies a potential mobile source problem or a potential roadway tunnel ventilation problem. If a potential problem were identified resulting from roadway tunnel exposures to mobile source pollutants, then it is possible that the most appropriate solution would be to increase tunnel ventilation rather than to reduce the vehicle emissions.

5) This preliminary example of sulfuric acid has not considered a specific margin of safety. It is possible that the inclusion of the roadway tunnel scenario as the controlling factor in the range of concern constitutes a margin of safety in view of conclusion 4 above, but no specific factor has been calculated.

6) The current vehicle fleet emission factor for sulfuric acid is 12 mg/mile, which is well below the lowest of the ranges of concern for sulfuric acid.

7) With respect to specific vehicle emission control designs, and referring to Table I, it appears that the emission control design/ vehicle categories that have emission factors most often appearing within the ranges of concern are Heavy Duty Trucks and Light Duty Diesel vehicles with trap-oxidizers (100 mg/mile).

FIGURE [2]
PERSONAL PARKING GARAGE

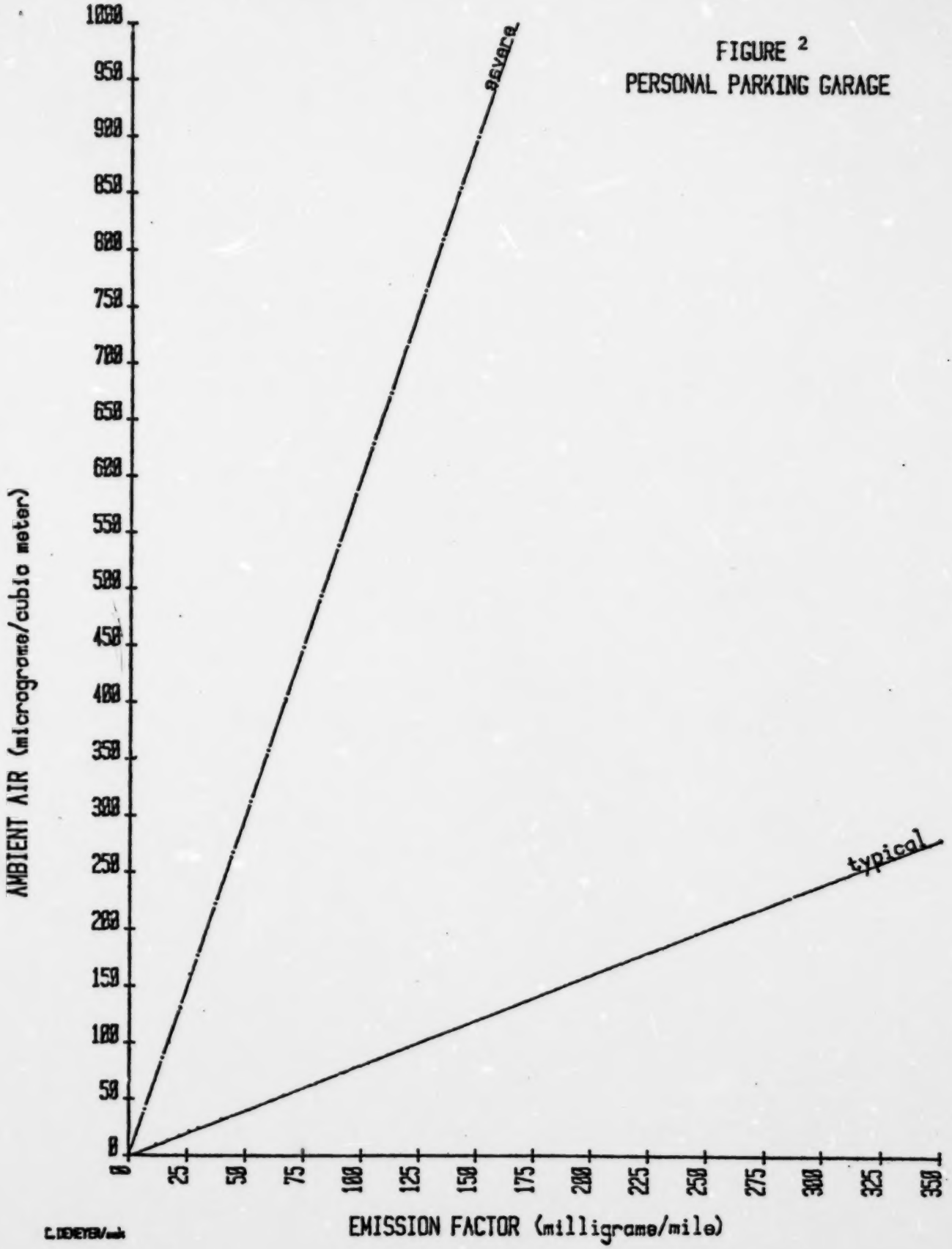


FIGURE 3
PARKING GARAGE

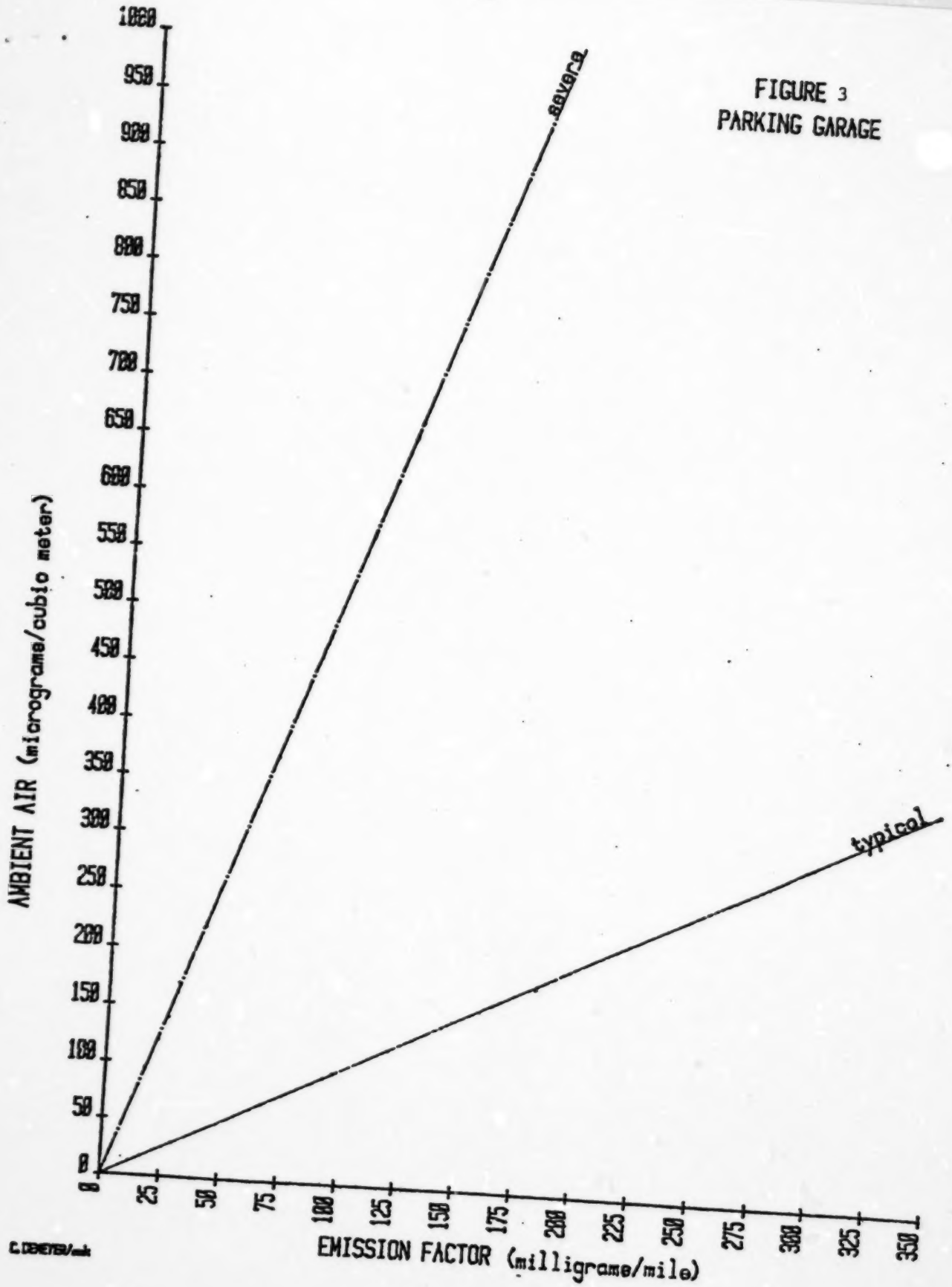


FIGURE 4
ROADWAY TUNNEL

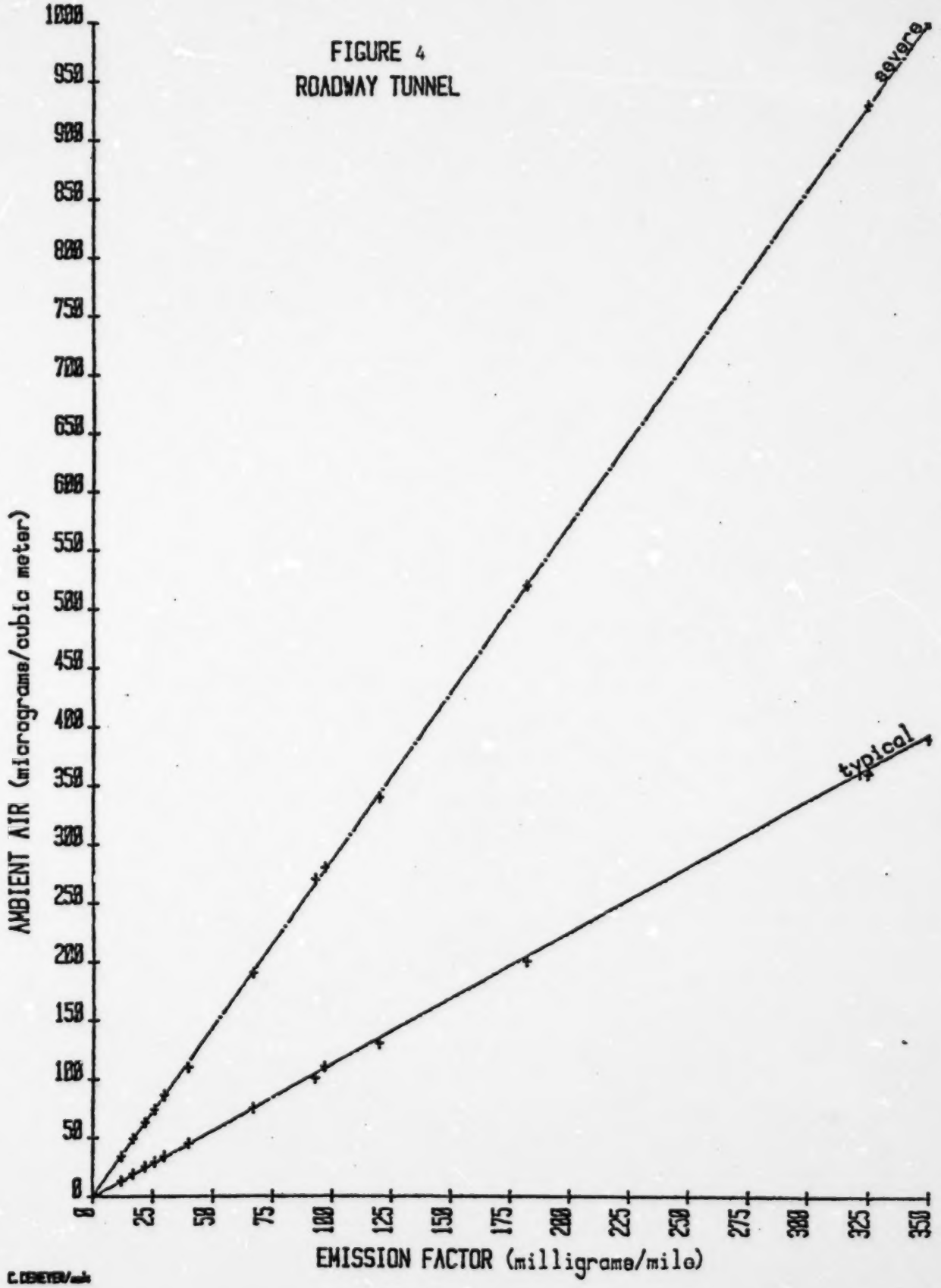


FIGURE 5
STREET CANYON

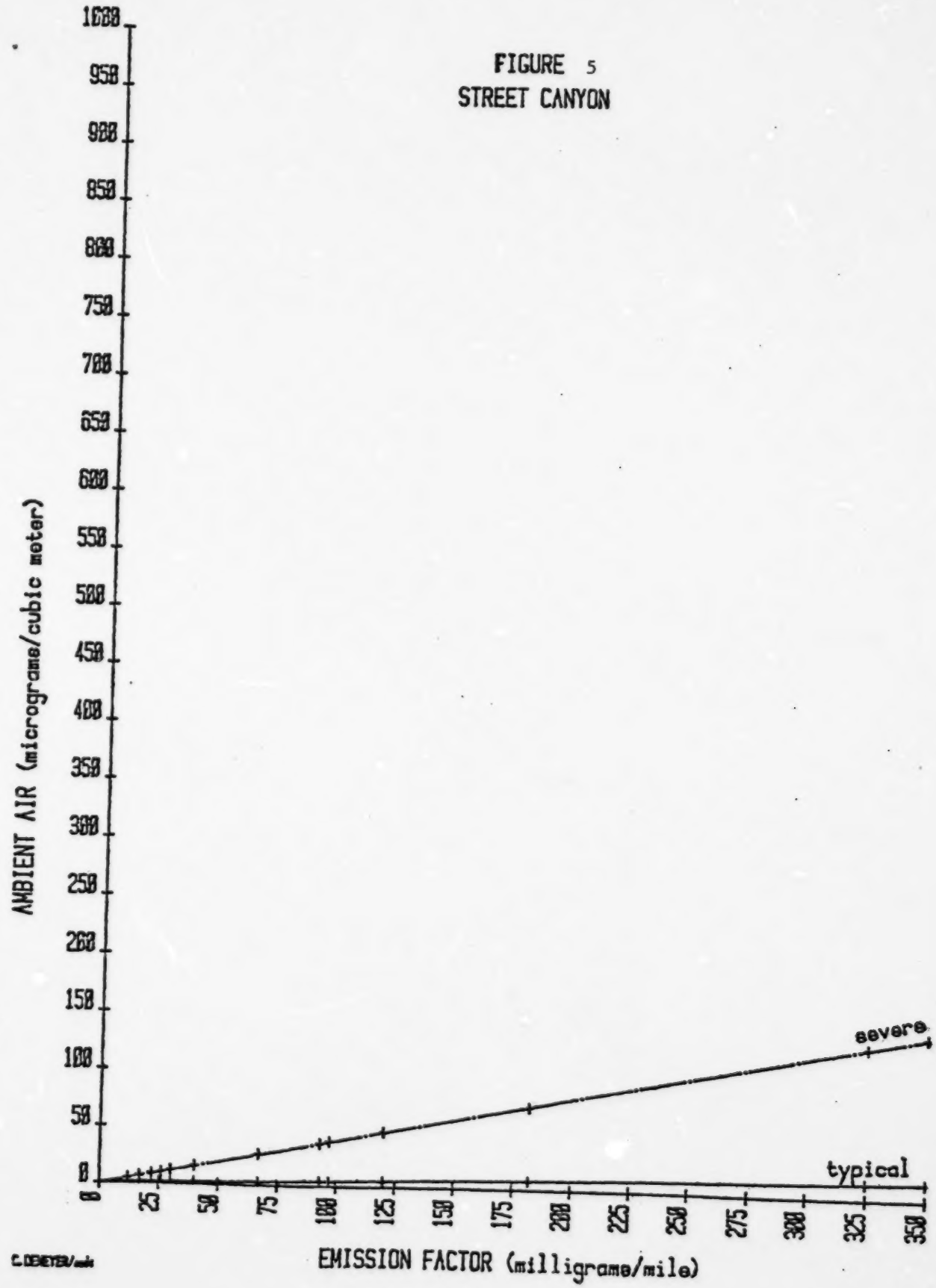
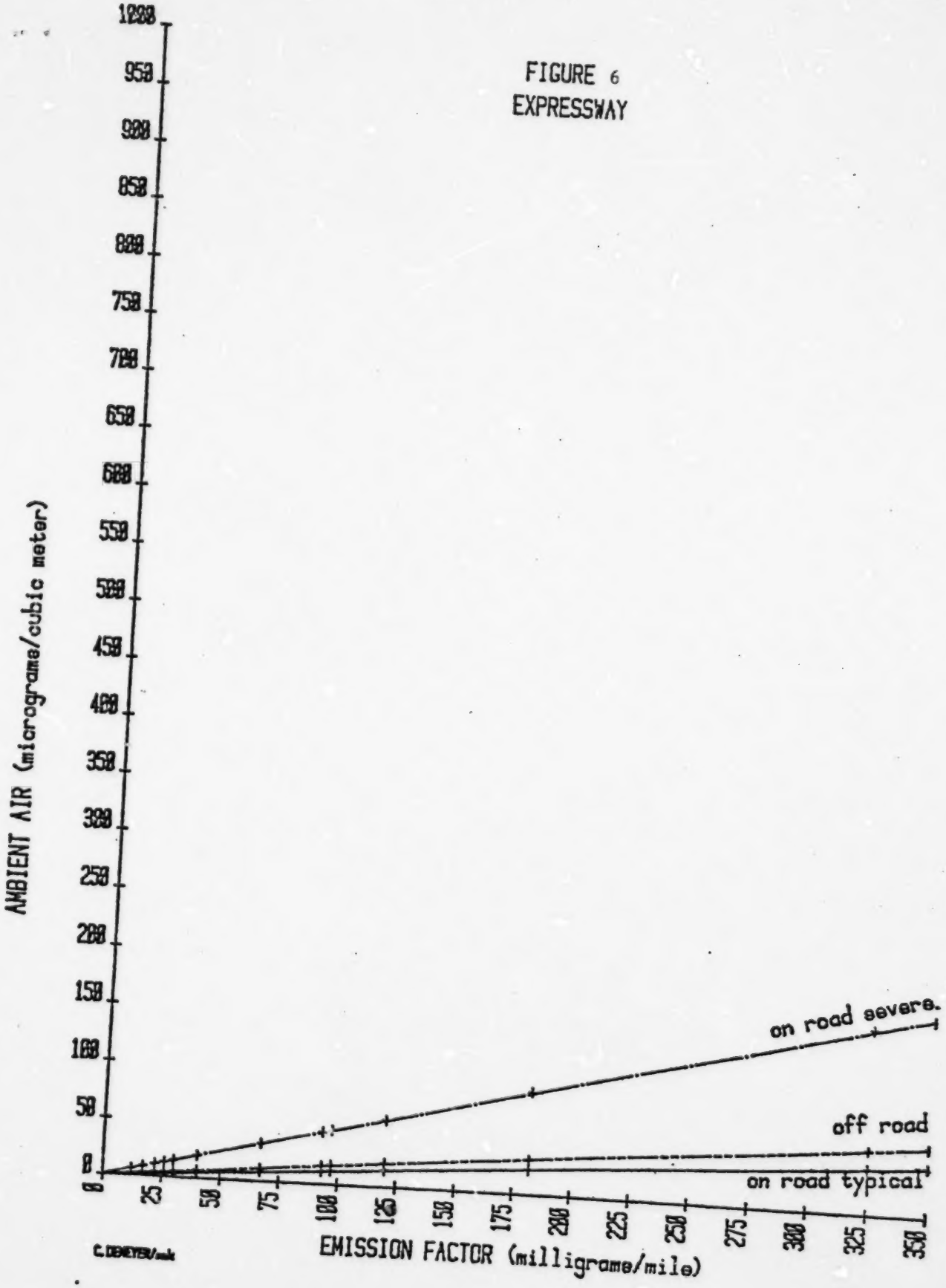


FIGURE 6
EXPRESSWAY



References

(1) "Characterization of Particulates and Other Non-regulated Emissions from Mobile Sources and the Effects of Exhaust Emission Control Devices on these Emissions," James E. Gentel, Otto J. Manary, and Joseph C. Valenta, Final Report EPA Contract EHS 70-101 with Dow Chemical Co., March 1973.

(2) "Sulfuric Acid Aerosol Emissions from Catalyst-Equipped Engines," William Pierson, Robert H. Hammerle, and Joseph T. Kummer, SAE Paper 740287, February 1974; SAE Transactions 83, 1233 (1975).

(3) "Sulfuric Acid Health Effects," Midwest Research Institute Report for EPA Contract No. 68-03-2928, 1981.

(4) U.S. EPA Advisory Circular 76, June, 1978.

(5) U.S. EPA Advisory Circular 76-1, November, 1978.

(6) "An Approach for Determining Levels of Concern for Unregulated Toxic Compounds from Mobile Sources," Robert J. Garbe, U.S. EPA, EPA/AA/CTAB/PA/80-2, July, 1981.

(7) The New Columbia Encyclopedia, Columbia University Press, New York, 1975, page 2649.

(8) "Sulfate Emissions from Catalyst-Equipped Automobiles," Charles R. Begeman, Marvin W. Jackson, George J. Nebel, G.M. Research Laboratories, SAE Paper 741060, October, 1974.

(9) "Emission of Sulfur-Bearing Compounds from Motor Vehicle and Aircraft Engines," EPA Report No. 600/9-78-028.

(10) "Regulated and Unregulated Emissions from Malfunctioning Automobiles," SAE Paper 790606.

(11) "Air Quality Assessment of Particulate Emissions from Diesel-Powered Vehicles," Pedco Environmental, Inc., March, 1978.

(12) "Mobile Source Emission Factors: For Low Altitude Areas Only," EPA Report No. 400/9-78-006, March,1978.

(13) Multimedia Environmental Goals for Environmental Assessment Volume 1, EPA Report No. 700/7-77-136a.

(14) "Emissions from Light and Heavy Duty Engines," EPA Report No. 460/3-79-007.

(15) "Exhaust Emissions from Malfunctioning Three-Way Catalyst-Equipped Automobiles," SAE Paper 800511.

(16) "Light Duty Diesel Catalysts," EPA Report No. 460/3-80-002.

(17) "Automobile Sulfate Emissions - A Baseline Study," SAE Paper 770166.